Newsletter

Project Overview

The **Carbo4Power** is a 4-year project, which started in November 2020. This project is funded by the H2020-EU.2.1.3. (€ 7.8 million – Grant Agreement 953192). The main objective is to develop a new generation of lightweight, high strength, multifunctional, digitalized multi-materials for offshore turbine rotor blades that will increase their operational performance and durability while reducing cost of energy production, maintenance and their environmental impact.

Partners

The Project partners are a multidisciplinary team of 18 partners (8 SMEs) from 8 countries, who provide technological know-how and industrial leadership, with well-balanced dissemination, communication & exploitation impact.

Partners' role in Project

R-NanoLab – NTUA - Project Coordinator

NTUA is one of the key partners in the project, responsible for the coordination and management of the project. Furthermore, regarding material research, **NTUA** will study the sizing of the carbon fibres that will be used in the project. The goal is to develop a sizing that will be compatible with the 3R resin and the NE materials as well as compatible with thermoplastic polymers that will be used for the comingled yarn process. Additionally, NTUA involved in the joining technology developments in wp1 and will participate in the round robin characterization as part of wp2. **NTUA** is involved in characterization and testing in a range of scale specimens from nano, macro and intermediate characterization (wp1-wp4). We are also involved in both the manufacturing and testing of the demonstrators by providing our know-how skills in composite materials. Finally, for the LCA strategies we are responsible to identify and liaise with advisory and standardization bodies for the progress and validation of **Carbo4Power** project.

Continius stabilization   Polymer Blending   Melt Spinning
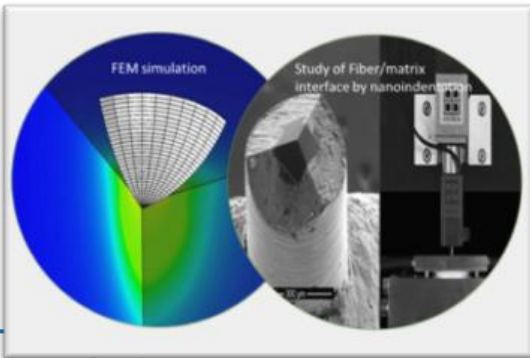
IRT Jules Verne

In **Carbo4Power, IRT Jules Verne** is responsible for the manufacturing of tidal blade demonstrators using its automated preforming line MADRAS associated with infusion process and one-shot process. In addition to the manufacturing aspects, of the wing turbine blades and tidal blades, the **IRT** is in charge of monitoring activities through the mechanical tests of both Wing Turbine and Tidal Blades and rapid Non-Destructive Testing.
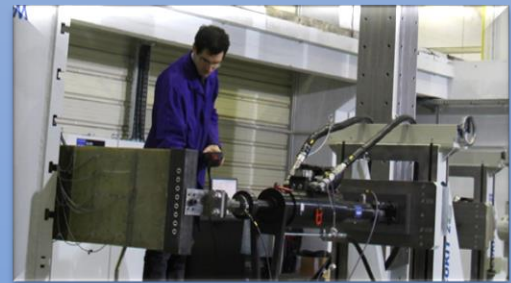

Multiaxial test bench

AIMEN Technology Centre

AIMEN is Work Package 5 Co-Leader. will lead the manufacturing tasks aimed at the construction of demo WTB module by means of Automated Composite Manufacturing Technologies, by Automated Tape Laying (ATL) and Advanced Infusion Technologies (VB/VARTM). Prior to the fabrication of the demo WTB module, **AIMEN** will assess optimum processing window for Advanced Manufacturing using the novel materials developed during this project will be implemented to the fabrication of demo WTB module.

Fundación CIDETEC

Development of nano engineered composite materials **CIDETEC** will apply 3 R technology and develop dynamic epoxy resin formulations for fiber reinforced composite materials Formulations will be adapted to the required specifications and manufacturing processes, and will contribute to improve reparability and recyclability.
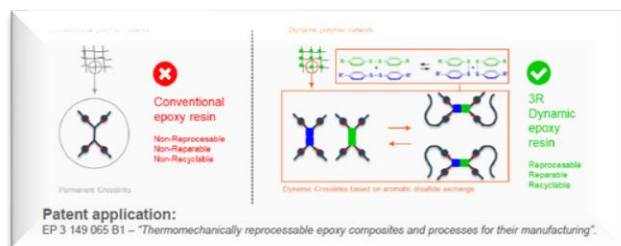

NE coatings with tailored functional properties **CIDETEC** will be taking part the activity on developing of functional coating tailored for improvement of durability and performance of offshore energy plants for WP 3 Based on **CIDETEC** expertise about omniphobic slippery surfaces, **CIDETEC** will apply the patented ionogel technology that prevent adhesion to the underlying substrate by superhydrophobic and self-cleaning properties to avoid the accumulation of fouling, based on low vapour pressure lubricants and low energy surface polymer materials.
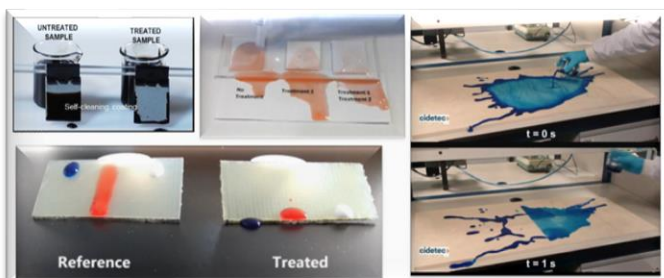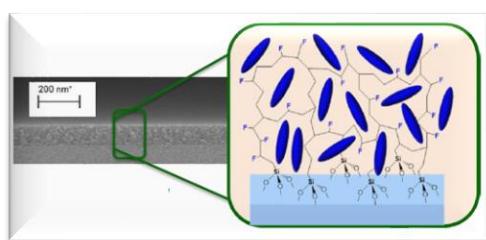
Innovation in Research and Engineering Solutions (IRES)

IRES is leading the Safety and Life Cycle Sustainability Assessments. The nanoparticle exposure risks are quantified through performance of on-site exposure measurements providing tailored tool solutions, while aiding on the nanosafety aspects via the development of best practices guidelines on nanomaterial handling and delivery of Safe-by-Design specific workshops. **IRES** is the responsible partner to perform the Social and Environmental Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) of the power blade production process and building Life cycle inventories (LCI) for the nanomaterials produced, as well as performing comparative impact assessments assessing various End-of-Life treatment options. Finally, **IRES** is involved in the development of decision-making algorithms via data processing tools and Machine Learning/Artificial Intelligence for embedded systems in the new power blades.
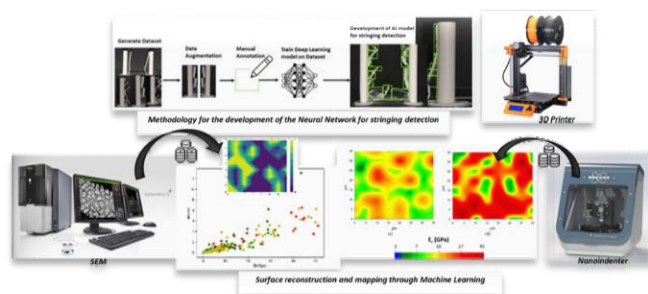

Sabella

SABELLA is in charge of the assessment and comparison of the different maintenance strategies for tidal turbines.

We are also involved in the design, manufacturing and testing of the TTB, as a **SABELLA** D12 prototype blade will be manufactured by IRT Jules Verne. **SABELLA** will also assist other partners in their task by providing data and recommendations from an industrial point of view.

Instituto Tecnológico de Aragon (ITAINNOVA)

In **Carbo4Power** **ITAINNOVA** is working on the development of innovative joining solutions as functionally graded adhesive joints and adhesive joints with debonding on-demand capabilities. In addition, **ITAINNOVA** is leading the Modelling and Design work-package, participating in many of the tasks defined there to support different materials/processes developments and design activities.
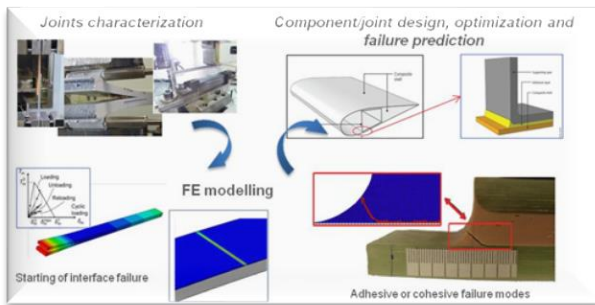
Sense IN

SENSE IN provides solutions for in-situ structural health monitoring of the demonstrators manufactured in the Carbo4Power project. QRS are designed to be totally integrated into the composite material at the nanoscopic level with materials developed during the project. This specific feature allows these sensors to be placed at critical locations determined by the partners who design and manufacture the blades. Monitoring includes determination of the deformation, wear-out and eventually shocks. **SENSE IN** provides the entire sensing solution from the individual sensor design to the monitoring software and event-tracking throughout the lifetime of the blades. All partners involved in material selection, blade design, manufacturing, or protection layers interact with **SENSE IN** at four stages of the project to ensure a smart integration of the solution. From the project start with material selection to the test level and data analysis for the demonstrators, **SENSE IN** designs, integrates the QRS and quantifies the induced physical modifications of the blades during preliminary tests, cycling tests and fatigue.

Fraunhofer IFAM

- Leader of WP2 "Durable multifunctional coatings"
- Material development with surface functionalities incl. drag-reducing riblet surfaces, fouling release surfaces and erosion resistant, icephobic materials
- Functionality testing on test coupons (lab-based)
- Components tests (seawater test rigs, ice wind tunnel)

The University of Birmingham

- Active-screen plasma activation and multi-functionalisation of CFs & GFs to increase the fibre/matrix interfacial shear strength; Triple-glow plasma activation and nano-particle deposition to effectively increase the electrical conductivity of CFs & GFs, thus reducing the risk of lighting damage.

- Evaluation of fibre/matrix interfacial shear strength via nano-pushout at sub-zero and elevated temperature in varying humidity environments using an environmental surface & interface testing platform.
- Nano-scratch and nano-impact will be used to simulate single hard particle abrasion/erosion to measure the abrasive/erosion wear resistance and thus the durability of erosion protection coatings; environmental SEM evaluation of anti-icing and self-cleaning behaviour of low surface energy coatings.
- As WP Leader to lead WP6 on Structural/Condition Monitoring.
- Structural health monitoring of wind turbine blades using advanced acoustic emission and vibration analysis coupled with innovative data processing based on machine learning and artificial intelligence.
- Development of digital twins using advanced FE analysis tools with input data from SHM system in order to evaluate damage evolution and estimate remaining lifetime of blades.

University of Strathclyde

We are involved in WP3 and WP6 of this project, including development of high fidelity CFD-structural numeric models for the analysis of full-scale blades and an IoT platform for remotely monitoring structure health of in-service blades, aiming at reducing maintenance cost while ensuring the service life of the wind turbine blades.
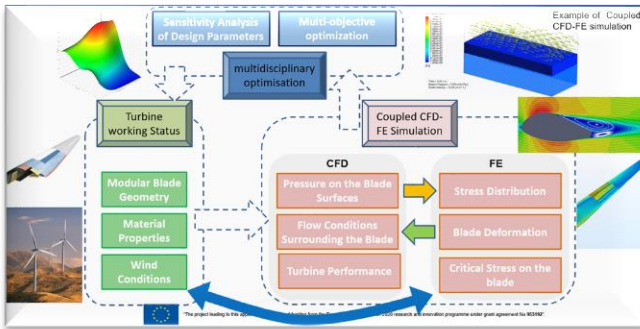
Cambridge Nanomaterials Technology Ltd

Cambridge Nanomaterials Technology Ltd (CNT). is leading the exploitation and dissemination activities of the **Carbo4Power** project. **CNT** is in charge of the project website (www.carbo4power.eu) leaflets, organisation of the Open Day workshops, Intellectual Property (IP) strategy, and preparation of patent landscaping reports. We are also involved in market research, business development and exploitation strategy of the project.
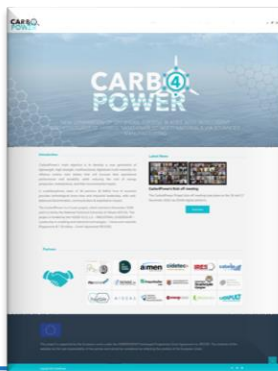
Haydale Composites Solutions Ltd.

Haydale has several roles within the Carbo4Power project as a product development specialist for advanced materials and material supplier. Developments to our electrically enhanced prepreg product, developed for the aerospace industry, will enable this technology to be used in the composite structures of wind turbine blades, improving the electrical conductivity of the composites to reduce damage from lightning strikes in service. Developments to our smart graphene heater ink product FLEX-C will provide active de-icing of the wind turbine blades in operation, reducing ice build-up and the down-time this causes to the wind turbine operation in an effort to reduce dangerous ice-throw events. Haydale will also supply a range of functionalised nanomaterial dispersions and silicon carbide whiskers for use by the partners within the Carbo4Power consortium. These materials will be utilised in applications such as erosion resistant silicon carbide coatings, hydrophobic/self-cleaning graphene coatings, nanomaterial enhanced sizing and adhesive formulations.

AIDEAS OU

Our main involvement is in Condition/Structural Health Monitoring (SHM). In this WP we will develop ML and AI-empowered analytics based on variety of models (SVMs Ensemble techniques, ANNs, CNNs and auto-encoders) that will be employed to maximise the efficiency of the SHM and on-demand de-icing systems for the wind turbine blades in real-time by encouraging unsupervised automated operation.

bionic surface technologies GmbH

bionic surface technologies GmbH is the simulation and design partner in the **Carbo4Power** project.

The main task is modeling and design of Riblets. This also includes the investigation of Riblet coating benefits on wind and tidal turbines through simulation. In addition, the previous Riblet design is measured with the unique BST Riblet test bench. Thus, evaluate the results of the simulation.

INEGI

In **Carbo4Power, INEGI's** composites unit will contribute to the development of advanced thermoplastic-based composite semi-products to be used in the manufacturing of more performing, with greater recyclability and able to provide multifunctionality to future wind blades and tidal off-shore structures. In particular, INEGI will be exploring the commingling technology to create tailored combination between thermoplastics and reinforcing fibres (either carbon or glass), which can be further use to create dry preform structures (before consolidation into composite structures) or to produce thermoplastic unidirectional composites tapes that can be further applied to produce composite structures through automated fibre placement with in-situ consolidation. **INEGI** can also validate the obtained material at coupon level before being into manufacturing processes to be developed. **INEGI** will also coordinate the activities in WP4 contributing with its experience in the design o composite structures and systems to specify the main characteristics required for the material to be developed. This will include evaluation properties from material to sub-component at demo levels using standard and in relevant environment test methodologies. Collaboration with the highly experience Wind Energy Unit of **INEGI** is foreseen. **INEGI** will also participate in the definition and development of the manufacturing processes and in the structural design making use, particularly, of its experience in the design and manufacturing of thermoplastic-matrix composite structures.
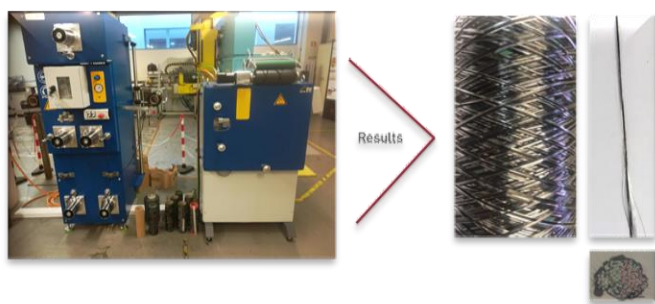
Commingling

ORE Catapult

ORE Catapult are joined with 18 other European partners in the Carbo4Power project funded by Horizon 2020. Carbo4Power's main objective is to develop a new generation of lightweight, high strength, multifunctional, digitalized multi-materials for offshore turbine rotor blades that will increase their operational performance and durability while reducing the cost of energy production, maintenance, and their environmental impact. During the 4-year project, **ORE Catapult** will utilise its knowledge and expertise in materials, blade design and testing to help achieve the project objectives. **ORE Catapults** main activities are:

- The development of a functionally graded recycled fibre adhesive carrier
- To utilise our models to determine modularity for segmented blades.
- The rain erosion testing of icephobic coatings.
- To drive the demonstration and validation of a wind turbine blade.

# BioG3D- New 3D Printing Technologies

BioG3D has developed methodology for CFD analysis of Wing Turbine Blade (WTB) bladelet by considering the operating conditions of the IEA 15MW reference turbine. Thus, the applied methodology contains 3D, steady incompressible, and RANS equations turbulent flow in the rotating frame of reference in order to simulate the WTB of the IEA 15MW turbine with and without bladelet (Figure 1). Moreover, bladelet 3D parametrized geometry model has been developed (Figure 2) for three main approaches of bladelet i.e. blended, downward and blended split. Main parameters for bladelet optimization such as cant angle and sweep angle have been applied in order to create optimized bladelet geometry that could affect in reduction of drag,

increase of lift along and maximizing of power coefficient. In addition, BioG3D has created the design optimization framework for CFD and FEA calculations. Among others the optimization framework includes the application of aerodynamic loads from CFD analysis as boundary conditions in FE analysis of the optimal designs of bladelet.

Along with CFD and FEA simulations, the physical testing approach will be applied by using scaled prototypes of the bladelets, which will be fabricated in order to export useful results for its aeroelastic behavior.
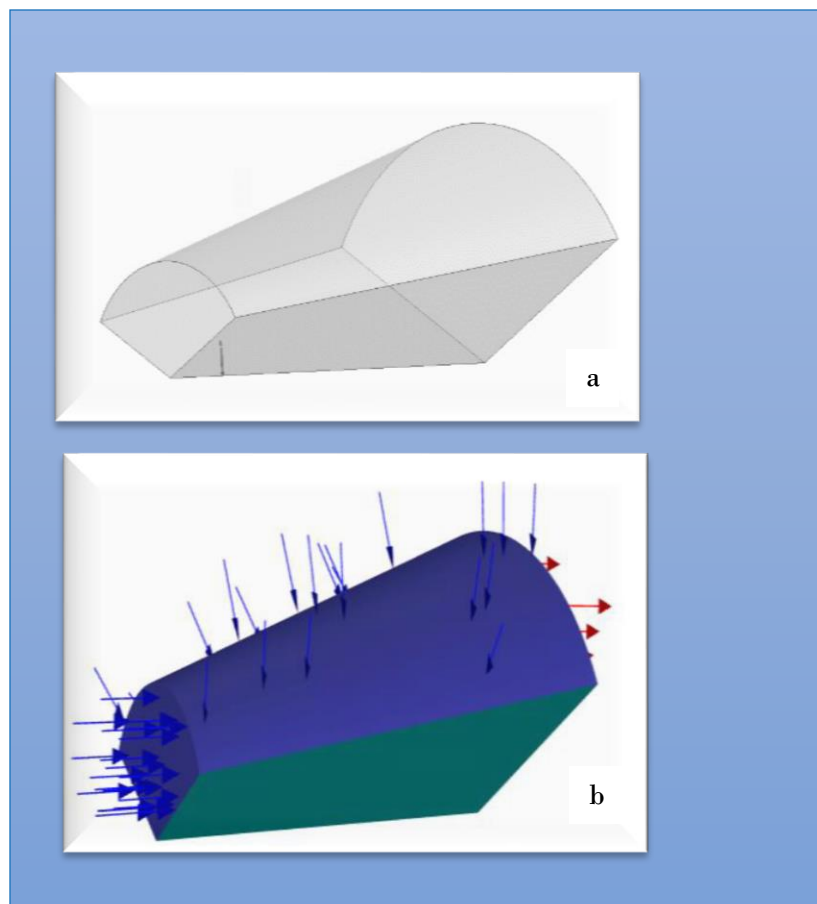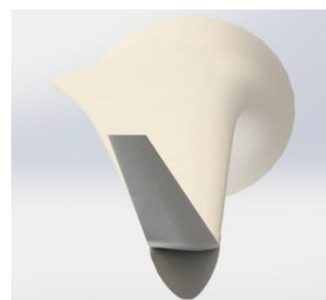
Fluid domain preparation for WTB simulation (a) and Boundary Conditions (b)
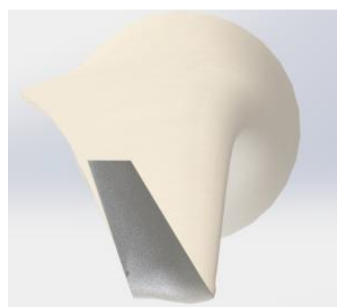
a

b

c

Approaches of Bladelet, blended (a), downward(b) and blended split (c)

News

Carbo4Power participated at the EuroNanoForum 2021 – 5 – 6 May

The **National Technical University of Athens- R-NanoLab – NTUA** (Project Coordinator), presented a poster at the virtual conference held on the 5 – 6 May 2021.
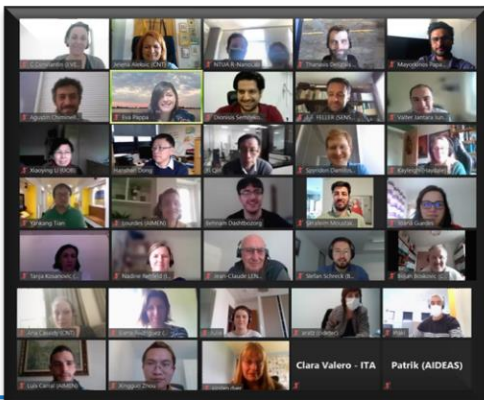

Carbo4Power participated in the JEC Connect – 1st – 2nd June 2021

A poster about the project was displayed on the **R-NanoLab** virtual exhibition stand, at the **JEC Connect** held on the 1st – 2nd June 2021. This event was held virtually.

Carbo4Power M6 Project Meeting – 18 -19 May 2021

The **Carbo4Power** M6 two-day Consortium Meeting took place on the 18 -19 May 2021 via ZOOM digital platform. Over 40 representatives from all partners organisations attended this 2-day meeting, where they presented the progress they have made during these first 6 months. The meeting finalised with a technical discussion and future plans for the next 6 months.

Carbo4Power present at the EoLIS Seminar – 4-5 Nov 2021

Dr. Evanthia Pappa from **NTUA** (Partner Coordinator), participated virtually at the *End-of-Life Issues and Strategies Seminar* organised by **WindEurope.** Dr Pappa participated in the session titled: "*Recycling blades part 1: An overview of existing and upcoming solutions*".

The seminar took place in Brussels on the 4th and 5th November 2021. The seminar aims to cover the challenges of what to do with ageing wind farms, repowering, and try to identify best practices and solutions.
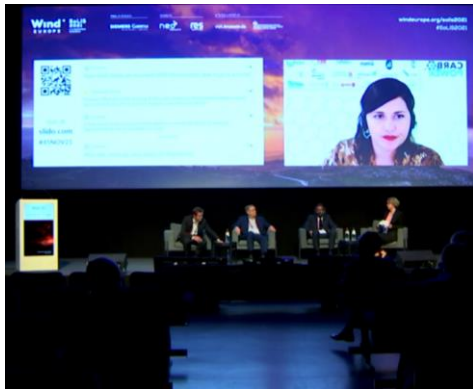
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For more information on the Carbo4Power project, please visit the project website at:

www.carbo4power.eu